SYNTHESIS AND CHARACTERIZATION OF NANO HYDROXYAPATITE POWDER FOR DRUG DELIVERY APPLICATIONS

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ABSTRACT:
Nano Hydroxyapatite (HA) particles were prepared by solution combustion method. Effect of various fuel combinations on the reaction condition and powder characteristics were investigated. The powder prepared under optimum condition show crystallite size of 10-20nm, particle size of 100-200nm and surface area of 10-20m^2/g. The zeta potential measurements of nano HA powder as a function of pH and addition of dispersant determine the condition of better dispersion in colloidal processing. The sinterability of nano HA was studied in the range of 1200° to 1400°C. A study on the use of nano HA for osteoporosis treatment by administering the nano HA loaded residronate sodium (drug) into rats has shown this formulation as a promising targeted drug delivery system.
Key words: Nano Hydroxyapatite, Synthesis, Processing, Drug delivery

INTRODUCTION:

Pure hydroxyapatite (HA) [$Ca_{10}(PO4)_6(OH)_2$] and its biphasic mixture with β-Tricalcium phosphate [β-$Ca_3(PO4)_2$] are potential Biomaterials for

- Bone fillers, Hard tissue implants, Coatings, Controlled drug delivery systems, Porous scaffolds for tissue Engineering

Nano crystalline particles due to high surface area & high surface energy

- Have high chemical activity
- Show increased dissolution and high bioactivity
- Enhanced growth rate of biological tissues

EXPERIMENTAL: Method Employed: Solution Combustion

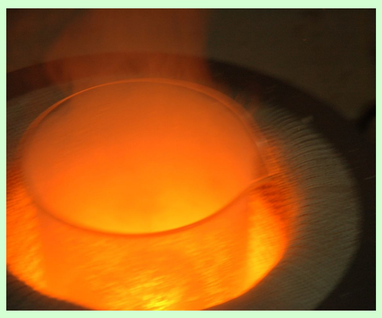
Calcium nitrate $Ca(NO_3)_2$ $4H_2O$ & Ammonium dihydrogen phosphate $(NH_4)_2HPO_4$: Precursors for Ca and PO_4
Urea [NH_2CONH_2] and Glycine NH_2CH_2COOH : Fuels

Characterisation of the powders:

- X-ray diffraction, IR spectra for powder and DTA-TGA of the gel
- Particle / agglomerate size distribution
- SEM & TEM: Size and Morphology
- Surface area and Particle size: BET method
- Surface charge and Zeta Potential analysis
- Drug Delivery for osteoporosis in rat model

RESULTS AND DISCUSSION

INVESTIGATIONS ON SYNTHESIS OF NANO HA & HA-TCP

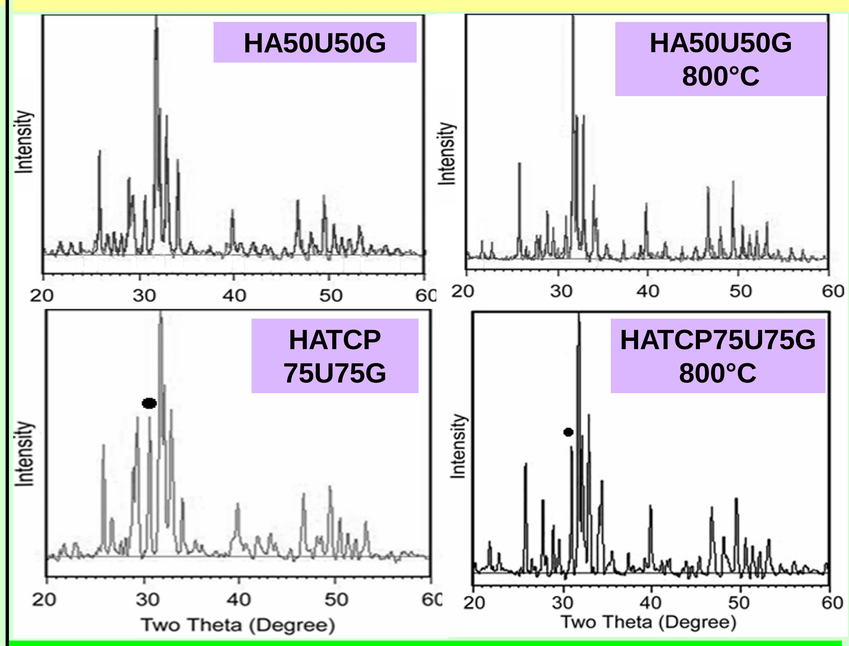


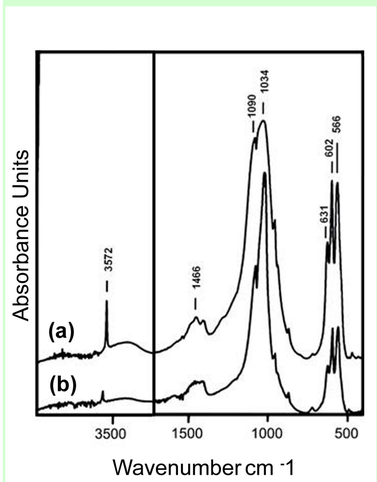
COMBUSTION IN A BEAKER

FLOW CHART OF THE PROCESS

Powder	Urea (%)	Glycine (%)	Combustion	Status
HA100U	100	-	No	Fumes
HA150U	150	-	No	Fumes
HA100G	-	100	Yes	Flame
HA50U50G	50	50	Yes	Flame
HA75U75G	75	75	Yes	Flame
HA50U100G	50	100	Yes	Flame

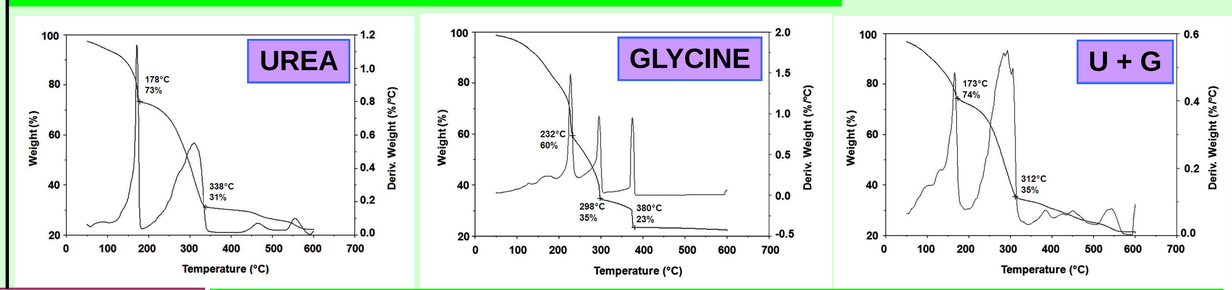
CHARACTERISATION OF NANO HA & HA-TCP POWDERS





IR SPECTRA OF HA & HA-TCP

XRD SPECTRA OF HA & HA-TCP POWDERS

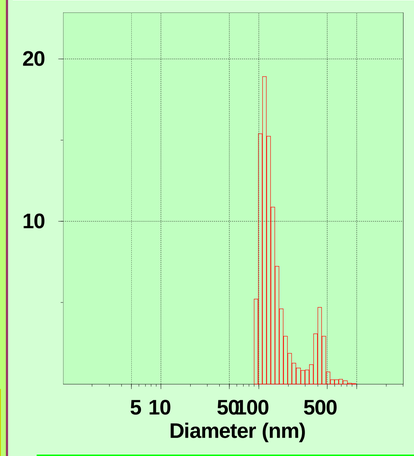


Nano HA for Osteoporosis Treatment in Rats

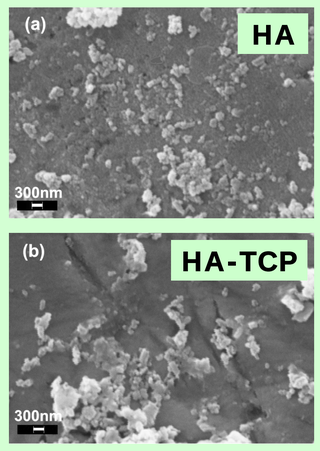
- Residronate sodium is a bisphosphonate drug for treatment of osteoporosis
- Nano HA granules (spray drying) loaded with residronate sodium (NHLR) by adsorption
- Osteoporosis was induced in rats & Drug was administered into them
- Bone Mineral Density (BMD), X-ray imaging, three point bending and histopathology studies were carried out after one month
- NHLR administered systems show higher BMD, increased elasticity and strength
- Nano HA having affinity towards bone tissue acts as promising drug delivery system in treatment of osteoporosis

Collaborative work with Dept. of Pharmacology, AACP, Bangalore
Paper accepted in J. Biomedical Nanotechnology, American Sci. Pub., Vol. 9, 2013

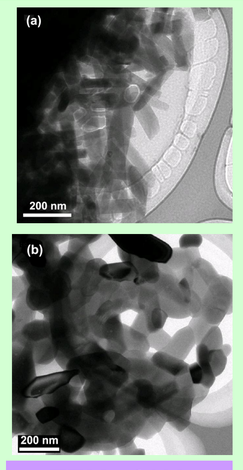
TGA for combustion precursor gels from different fuels



Particle Size Ananlysis



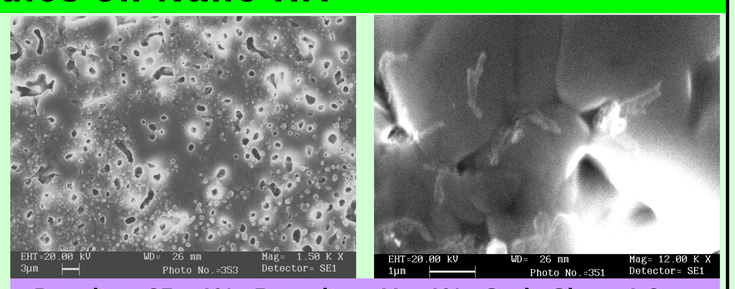
SEM of HA & HA-TCP



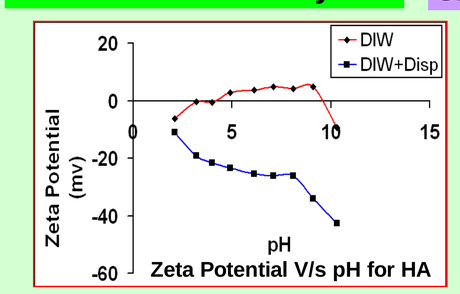
TEM of HA

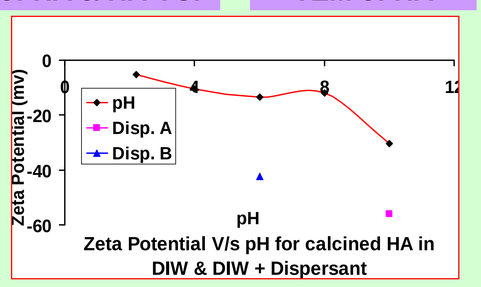
Sintering studies on Nano HA

Sample	Sintering Temperature (°C)					
	1200		1300		1400	
	1h	2h	1h	2h	1h	2h
HA – As prepared	66.4	-	70.7	-	75.3	76.9
HA – Milled	-	-	81.1	84.8	89.0	89.8



Density = 85 ± 1%, Porosity = 11 ± 1%, Grain Size = 1-3µm





ZETA POTENTIAL MEASUREMENTS

CONCLUSIONS:

- HA and HA-TCP biphasic powders having crystallite size 10-20nm, particle size 100-150nm, surface area 10-20m^2/g surface area were prepared by simple, cost effective, one step reaction through solution combustion method.
- The type of fuel, ratio of fuel to oxidizer and the fuel composition having control over the combustion reaction affects the crystallite phase, the size and morphology of the powders produced.
- The nano HA powder was sinterable to ~90% and porosity ~10% with grain size of 1-3µm
- The nano HA having affinity towards bone tissue acts as a promising candidate in targeted drug delivery system for treatment of osteoporosis